LA-UR-01-4029

Title: **Temperature Measurements Collected from an Instrumented Van in Salt Lake City, Utah as part of URBAN 2000**

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Submitted to: International Society of Environmental Hydraulics Conf.
Tempe, AZ, December 2001

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Introduction

Measurements of temperature and position were collected during the night from an instrumented van on routes through Salt Lake City and the rural outskirts. The measurements were taken as part of the Department of Energy Chemical and Biological National Security Program URBAN 2000 Field Experiment conducted in October 2000 (Shinn et al., 2000 and Allwine et al., 2001a). The instrumented van was driven over three primary routes, two including downtown, residential, and "rural" areas and a third that went by a line of permanently fixed temperature probes (Allwine et al., 2001b) for cross-checking purposes. Each route took from 45 to 60 minutes to complete. Based on four nights of data, initial analyses indicate that there was a temperature difference of 2-5 °C between the urban core and nearby "rural" areas. Analyses also suggest that there were significant fine scale temperature differences over distances of tens of meters within the city and in the nearby rural areas. The temperature measurements that were collected are intended to supplement the meteorological measurements taken during the URBAN2000 Field Experiment, to assess the importance of the urban heat island phenomenon in Salt Lake City, and to test the urban canopy parameterizations that have been developed for regional scale meteorological codes as part of the DOE CBNP program.

Instrumentation and Software

A Chevrolet cargo van was instrumented with a thermistor probe and a GPS unit for obtaining temperature and vehicle position, respectively. The thermistor was mounted on a 1.5 cm diameter PVC sting and the GPS unit was taped to the roof. The sting was affixed to the van between the front and rear passenger side doors with the temperature probe approximately 25 cm above the vehicle roof and 2.5 m above the ground (Fig. 1). Preliminary experiments indicated that the temperature probe at this position was not influenced by heat generated by the van.

The temperature data were taken using a YSI 4600S (Transfer Standard) Precision Thermometer in conjunction with an "in-house" Matlab data acquisition program run on a PC laptop. Time and temperature data were acquired through a serial (RS-232) interface at a rate of one sample every 524 milliseconds. The time constant of the YSI 4600S is one second in an oil bath and five to ten seconds in air, the resolution is 0.01 °C, and the accuracy is ± 0.025°C from 0° to 50°C. Our unit was calibrated at five points with a YSI 052 Bird Cage Air Probe and has certified NIST traceability.

The van position was obtained with a DeLorme Earthmate GPS. Position, time, and velocity data were saved to a file via a serial connection interface using DeLorme's Topo U.S.A. 2.0

software on a second PC laptop. Satellite accessibility limited the data rate of the GPS system and caused it to be slightly irregular, ranging between 0.25 and 1 Hz. The horizontal accuracy of the GPS varied between 10 and 15 meters while moving. The speed range over which the van traveled was from 10 to 30 mph with frequent stops.

Route Description

We chose two major routes that each took about an hour to drive and covered many landuse types, including the urban core, light industrial zones, strip malls, residential neighborhoods, and rural areas. For cross check purposes, a third route was occasionally driven that passed by an array of temperature sensors (called HOBOS) mounted on telephone poles by a team of researchers from Pacific Northwest National Laboratory (Allwine et al., 2001b).

Most of the routes included a trip through the downtown core. The buildings in this area are a few stories to tens of stories high and cover a relatively small area of about ten square blocks. In order to compute an urban-rural temperature difference, we drove two routes that took us to two different “rural” areas. On one route, the rural area began near a golf course and city park, and included pasture and marshy land, but a refinery bordered the "rural" area to the north, residential neighborhoods to the south, and the freeway to the east. The second “rural” route was farther out of the city to the west, and included larger tracts of vacant vegetated land, but there were still warehouses intermittently interspersed throughout. The first rural route is referred to as the “Golf Course” route and the second one as the “Brighton Creek” route.

The elevation in the downtown core is about 4300 feet above sea level. To the west it is relatively flat, with a maximum elevation change of about 70 feet over ten miles. To the east are the foothills of the Wasatch Range. There is a gentle rise of about 100 feet as one travels east from the downtown area past the HOBO sensors. As the University of Utah is approached the elevation change increases, reaching about 4700 feet at the end of our route. There are also several canyons that open into the city, including City Creek Canyon to the northeast of the downtown core and Dry Creek and Red Butte Canyons to the north and northeast of the University of Utah, respectively.

Results

Experiments were performed over four nights between Oct. 22 and Oct. 26, 2000. On each night, the data sets were broken down into sub-experiments lasting from 45 to 60 minutes on average, allowing enough time to make a complete circuit through the downtown core and one of the rural routes. On nights when shorter routes occurred it was generally due to losing GPS battery power. Table 1 lists the time intervals, the routes driven, cloud cover, and wind conditions for each experiment. Further information, including satellite images, weather maps, and basin scale wind vector plots can be found in the experimental data report (Brown and Pardyjak, 2001).

For illustrative purposes, we present measurements from two sub-experiments below. Note that our goal is to provide an overview of the data available, not to give detailed discussions of the mechanisms responsible for the spatial and temporal patterns. A follow-on paper will address these concerns and will utilize other data sources as well.

Figure 2 shows the temperatures measured during Expt. 1B. This route began at 11:40 pm on Oct. 22 just to the west of downtown, passed through the downtown core, proceeded onto the Brighton Canal rural route, and finished up in the downtown area at 12:23 am. A 6 ºC maximum temperature difference was measured between the urban and rural areas. It appears that the warm regions have extended westward, perhaps indicative of an urban thermal plume. A strong 2 to 4 degree gradient occurs over a relatively short distance. Analysis of wind data indicates that they are relatively strong from the east at this time.

Figure 3 depicts the temperatures measured during Expt. 4A, which commenced at 11:35 pm on Oct. 25 to the west of the downtown core. The route included the downtown core, the Golf Course rural route, the residential area to the southeast of the downtown core, and finished south of the downtown core at 12:36 am. The urban-rural temperature difference was about 3 ºC, although a slightly larger temperature difference occurs if the residential temperatures are used for this case. The cooling associated with the City Creek Canyon drainage is apparent along the N. Temple and State St. (Hwy. 89) intersection. Temperatures are relatively warm along the N. Temple strip mall section, but cooler on the return route. There is also a peculiar warm area along the southwest corner of the Golf Course rural route which didn't show up on most other nights.

Summary & Conclusions

Using an instrumented van, temperature measurements were obtained in Salt Lake City and surroundings over four nights during the URBAN 2000 field experiment. The data will be utilized to complement other datasets collected during the experiment and to better understand the nature of the urban heat island in Salt Lake City. The data is available directly from the authors in an ascii text format and includes five columns of tab-delimited data: time (MDT), latitude, longitude, speed (mph), and temperature (C).

References

Allwine, K.J., J.S. Shinn, G.E. Streit, K.L. Clawson, and M. Brown (2001a) An Overview of *URBAN 2000* - A Multi-Scale Field Study of Dispersion Through an Urban Environment, to be submitted to the Bulletin of the American Meteorological Society.

Allwine, K.J., J.D. Fast, and J.C. Torcolini. (2001b) Measured Surface Temperature Distribution Across an Urban Area. In Proceedings of the 3rd International Symposium on Environmental Hydraulics. Arizona State University, December 5-8, 2001, Tempe, Arizona.

Brown, M. and E. Pardyjak (2001) Temperature Measurements for Investigation of the Salt Lake City Urban Heat Island - Data Report for the DOE CBNP URBAN Field Experiment, Oct. 2000. LA-UR-01-3176. Los Alamos National Laboratory, Los Alamos, New Mexico.

Shinn, J.H., K.J. Allwine, and G.E. Streit (2000) The DOE URBAN field program for 2000-2004, 3rd AMS Urban Env. Symp., Davis, CA, LA-UR-01-1467.

Table 1 – Experiment Descriptions

Expt. No.	Date	Time (MDT)	Route	Cloud Cover	Winds Over City (C) & Outskirts (O)
1A	Oct. 22	22:38 - 23:21	downtown golf course rural	broken high	C: strong easterly O: light to med. & variable
1B	Oct. 22	23:40 - 00:23	downtown canal rural	scattered high	C: strong easterly O: light & variable
1C	Oct. 23	00:35 - 01:40	downtown HOBO & Univ.	scattered high	C: med. easterly & light northerly O: light southerly
2A	Oct. 23	23:44 - 00:28	downtown golf course rural	broken high	C: light & variable O: med. southerly
2B1	Oct. 24	00:52 - 01:48	downtown HOBO & Univ.	scattered high	C: light southeasterly O: med. southeasterly
2B2	Oct. 24	01:48 - 02:44	downtown canal rural HOBO & Univ.	broken mid-hi	C: med. southeasterly O: light to med. southeasterly
2C	Oct. 24	02:52 - 03:26	downtown golf course rural	broken mid-hi	C: med. southeasterly O: med. to strong southeasterly
3A	Oct. 24	22:33 - 23:34	downtown golf course rural HOBO & Univ.	broken high	C: light southeasterly to easterly O: light southeasterly to southerly
3B	Oct. 24	23:39 - 23:58	downtown	broken high	C: light to med. southeasterly O: light southeasterly
4A	Oct. 25	23:35 - 00:36	downtown golf course rural	scattered high	C: light easterly to southeasterly O: med. to strong southeasterly
4B	Oct. 26	00:50 - 01:12	downtown	scattered mid	C: light easterly to southeasterly O: strong southeasterly
4C	Oct. 26	02:12 - 03:25	downtown golf course rural	scattered mid	C: light to med. southeasterly O: med. to strong southeasterly
4D	Oct. 26	03:53 - 05:17	downtown both rural routes HOBO & Univ.	broken mid	C: med. to strong southeasterly O: med. to strong southeasterly
4E1	Oct. 26	05:23 - 06:08	downtown canal rural	broken mid	C: med. to strong southeasterly O: med. to strong southeasterly
4E2	Oct. 26	06:08 - 07:26	downtown both rural routes	overcast	C: med. south to southeasterly O: med. to strong southeasterly

* MDT (Mountain Daylight Time) was the local time during the experiment.

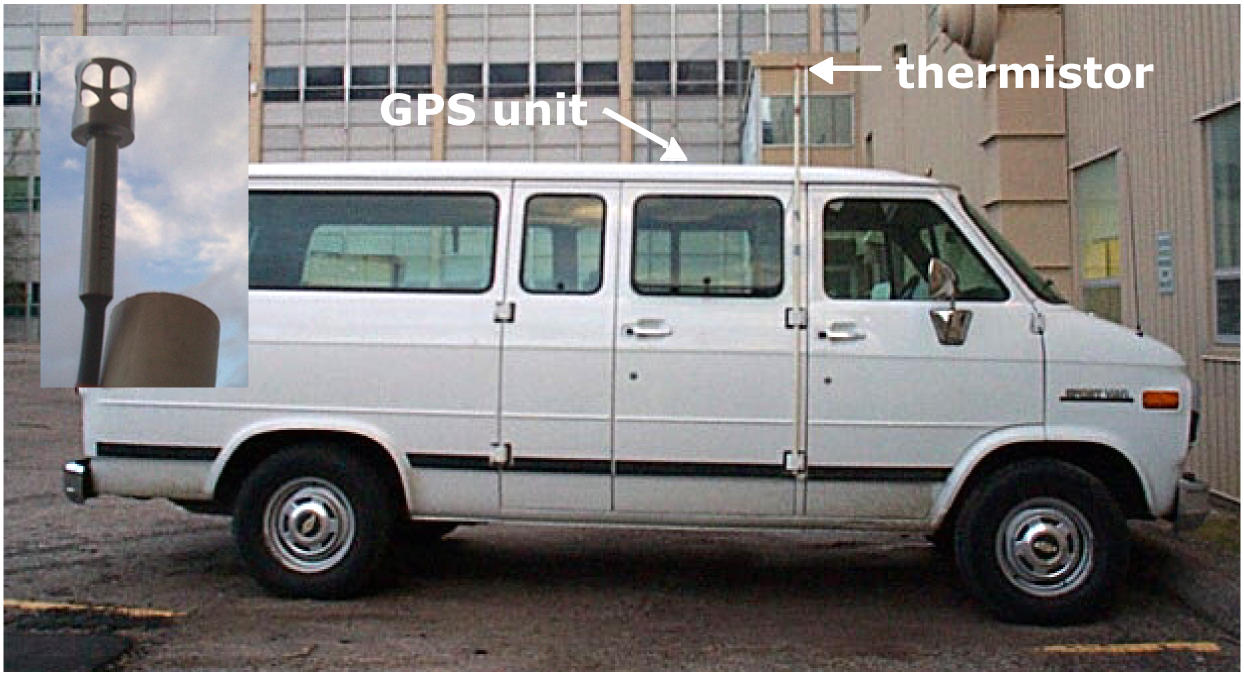

Figure 1. Van with GPS unit and temperature probe. The inset shows a close-up of the protective bird cage basket that shields the thermistor-type temperature probe.

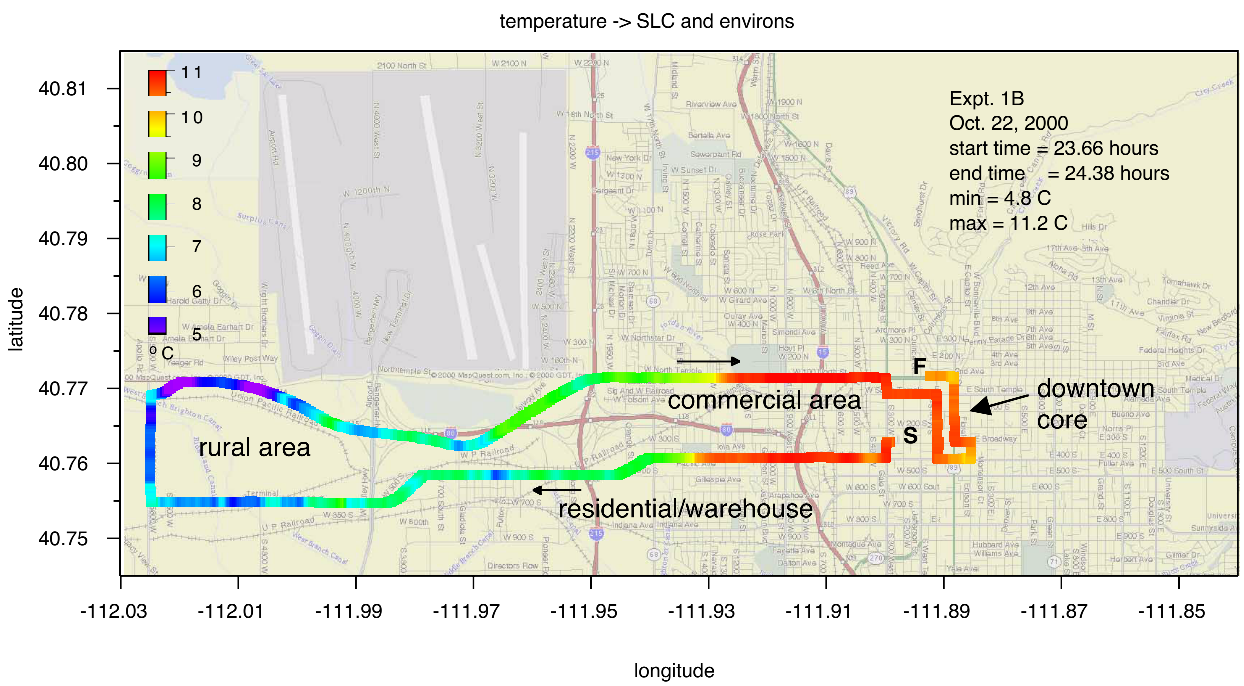

Figure 2. Temperature measurements made between 11:40 pm and 12:23 am along the Brighton Creek route. Warmer temperatures are found to the east in the downtown and commercial areas and cooler temperatures are found to the west in the residential and rural areas. The winds were blowing out of the east at this time. S – start point, F – finish point.

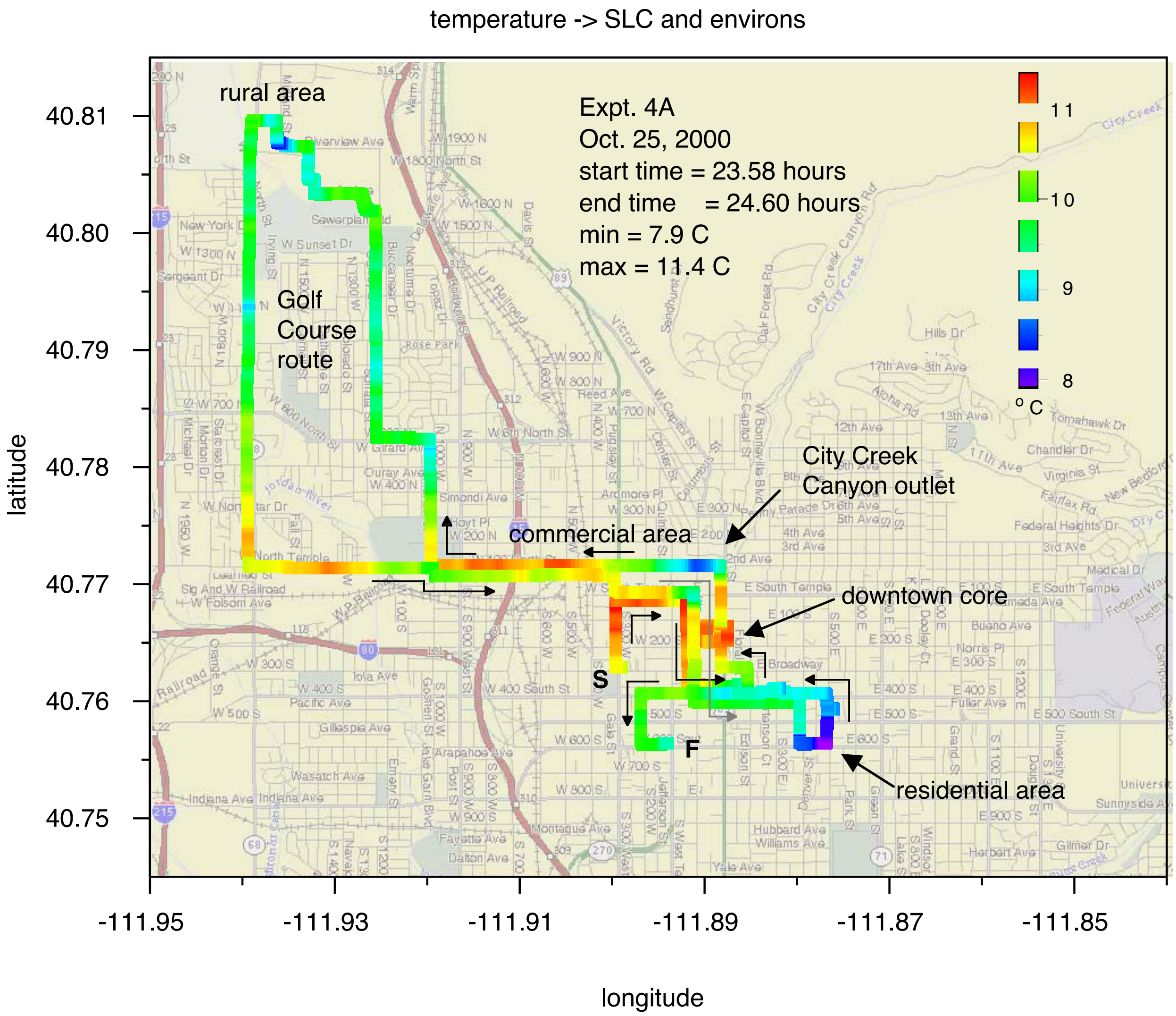

Figure 3. Temperature measurements made between 11:35 pm and 12:36 am along the Golf Course route. Warm temperatures were measured in the downtown core, but the coolest temperatures were found in the residential area to the southeast and at the City Creek drainage outlet. S – start point, F – finish point.